Albemarle Sound Hydrographic Survey

A Prototype for 'Coastal Resilience Charting'

Overview

One of the **longest estuaries** in the state of North Carolina, the **Albemarle Sound** stretches inland from the beaches of the Outer Banks to miles of open water, to meandering and interconnecting rivers and expansive wetlands, marshes, and swampland that converge with the Sound. This **complex and varied landscape** also provides a diversity of boating, watersports, fishing, and wildlife viewing activities to communities of the region. The Sound has not been surveyed for navigation/marine hazard purposes since the 1920s and the region has experienced a drastic degradation in water quality and sharp declines in fishing stocks. Following a **pioneering survey approach** now termed '**Coastal Resilience Charting**', the NOAA Office of Coast Survey contracted NV5 to collect new hydrographic data for 475 nmi^2 within the Albemarle Sound. The new approach was geared to serve two purposes using the resulting high-resolution bathymetric products – to **update National Ocean Service charting products** and to **provide data to support coastal resiliency modeling efforts** (e.g., inundation mapping, salinity gradient mapping, nutrient pathways, sediment transport models, habitat mapping, and coastline change analysis) through digital elevation model (**DEM**) **revisions to the National Water Model** (NWM). Although the unconventional nautical charting environment of the Sound would require an equally unusual charting survey approach, and the bathymetric mapping goals would also test the limits of our hydrographic survey techniques, **NV5 rose to the occasion** to bring to NOAA OCS cost effective products that would meet the multiple needs of coastal generations to come.

Complexity and Innovation

The Albemarle Sound hydrographic survey presented us with **unique spatial and temporal challenges** which required **sophisticated planning and agility** to meet the project goals, specifications, and NOAA charting standards. With the lack of modern bathymetry and the extremely shallow nature of some portions of the estuary, designing the **diverse depth dependent survey** was among the most challenging endeavors undertaken by NOAA and our team. The complexity of the study area first required extensive reconnaissance and survey work to establish the Navigable Area Limit Line (NALL) and inshore limits for our multi-vessel approach. To effectively cover the extensive geographic footprint of the Albemarle Sound with its varying depths and survey characteristics, NV5 deployed a fleet of **six survey platforms**, each designed to navigate specific environmental conditions. To enable **comprehensive mapping of the underwater landscape**, the survey approach required the use of six platforms including two Uncrewed Surface Vessels (USVs) each configured with **different combinations of three sensors** to enable covering the diversity of depths surveyed by each within a single day. **Multibeam echosounders (MBES)** were used to map full coverage bathymetry for large swaths in deeper waters; **singlebeam echosounders (SBES)** were used to collect data along single transects in shallower waters, and **sidescan sonar (SSS) sensors** enhanced data collected with SBES by USV to map the seabed sediment characteristics, identify and characterize targets, and assess potential hazards in shallow river tributaries where vessels could not gain safe access.

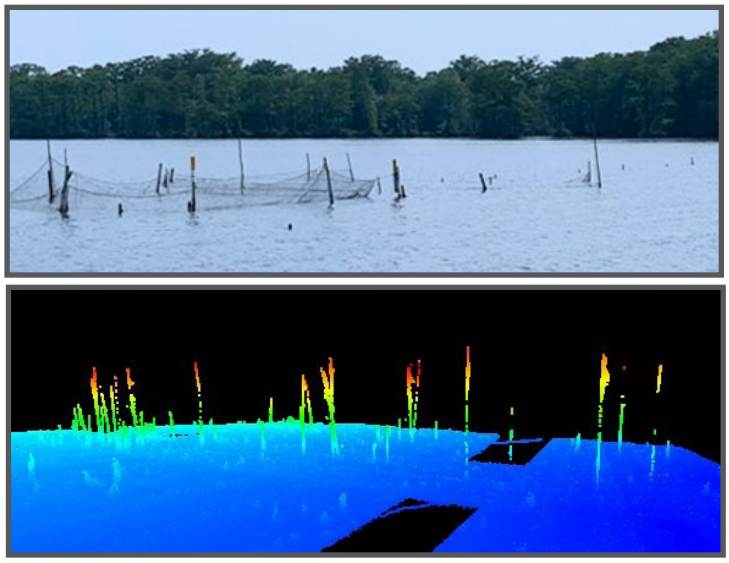
Diversity of NV5 survey vessels and USV on the open waters of Albemarle Sound, NC.

B. Surveying / Field Data Collection, Albemarle Sound, NC

NV5

With the predominately shallow nature of the study area, a very large portion of the Albemarle Sound AOI was collected with SSS. These areas were characterized by extensive submerged forests, the presence of baitfish schools, pervasive thermoclines, and a significant number of commercial/recreational fisheries operations. Normally when surveying in deeper water, there is more flexibility in the sensor placement within the water column to avoid issues with thermocline refraction or interactions with submerged features. In shallow water, the towfish altitude allowance was severely constrained and so deploying the SSS sensors **required a tailored approach** to achieving quality data. The data were reviewed immediately after collection to assess the degree to which these factors influenced meeting the data quality standards, and decisions to re-collect data on a repeat pass, of which there were many, were made. With six platforms (three operating 24 hours for much of the project), it took NV5 **nine months** to complete **over 17,500 linear miles** of hydrographic survey for the Sound.

Expedient review and QC of the data was critical for decisions to re-collect data, and to keep the disparate datasets organized. With the **unprecedented volume of data collected daily**, we realized that to enable effective hydrographic data management and review would require a sophisticated Geographic Information System (GIS). To enable us to track, manage, and report on multiple aspects of the survey for near-real time situational awareness of the Albemarle Sound project, we utilized ArcPro to design a single **cloud-based GIS web application data validation tool** -- the Survey Information Management System (**SIMS**) -- for all data review and project management. SIMS allowed us to conduct QC on mosaics from the composite dataset for quick assessment of the quality of data on a line-by-line or area-by-area basis. The SIMS tool was also instrumental in **keeping the data processing workflows organized** on the back end. We organized the project data into seven survey sheet tile areas, which allowed team members to focus on comprehensive datasets from all sensors for specific segments of the survey. Finally, the GIS framework also enabled us to generate detailed maps and reports essential for communicating findings to stakeholders and highlighting previously uncharted features of concern.

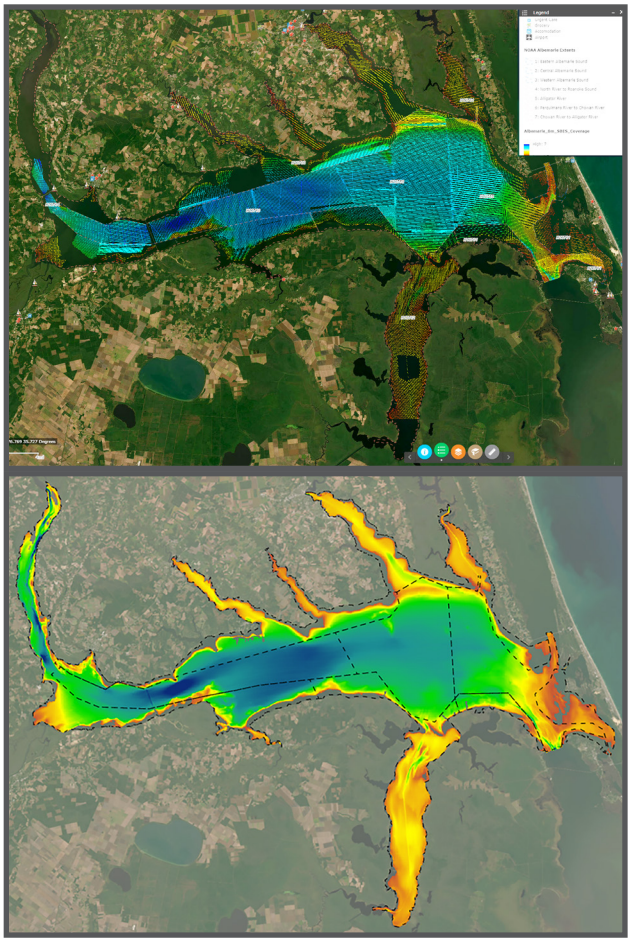


Images above (photo and data image) show submerged forest obstruction and fishing equipment in a shallow zone modeled by NV5's hydrographic sensors..

Over 100 dangers to navigation (DToNs) were discovered and necessitated immediate reporting to ensure maritime safety. Along with the over 3,000 features identified by SSS, these uncharted bottom features were an additional and unexpected deliverable to report on while upholding charting standards. The SIMS ArcPro tool is a **unique application of GIS in the hydrospatial industry** which promises to improve efficiency, data quality, and value of the data to the user as first-time-right.

Also unique to this project were the adjustments we made to our data processing workflow to ensure that **both goals of nautical charting and coastal resiliency mapping could be met** by the data products that we delivered. SBES with concurrent SSS is not normally used for nautical charting (where accompanying measures of uncertainty are required), so we adapted a legacy-based sounding processing approach for SBES to the nautical charting standard, **blending the use of several different mapping/processing software** to ensure the data could be used for nautical charting. Similarly, in addition to the traditional non-interpolated

grids utilized for charting, **interpolated grids** were another desired deliverable outcome from the **coastal resiliency stakeholders** of the project. There were no standardized specifications for this deliverable, leaving the solution to our experienced data processing gurus. Integrating the diverse datasets involved testing multiple gridding methods that would result in the most accurate merged models of underwater features and complex bathymetry. Instead of applying a generalized nearest-neighbor approach across the entire study area, our team tailored a different gridding method for each of the survey sheets based on the nature of the data collected within each. Data from one sensor was cleverly used to inform and interpret data from another (e.g., we used the MBES to recover artifacts in the SSS imagery, etc.). Although this **ingenious approach** took more effort on the part of our processing team, it resulted in a more reliable picture of hydrographic features and topography of the Albemarle Sound to support countless use cases in studies of coastal resiliency.



SIMS GIS data for all sheets (top) and final hydrographic DSM (bottom) of Albemarle Sound, NC.

Future Value & Client Satisfaction

This project **advances the hydro-geospatial profession** by demonstrating the **viability of multi-purpose 'Coastal Resilience Charting' projects** to more efficiently (and for less cost) support multiple stakeholders and provide answers to a greater diversity of questions at the same time. Our innovative multi-sensor data collection and management approach serves as a model for future projects in similar environments that ambitiously combine charting and coastal resiliency goals. By **supporting countless applications**, the project **benefits the health, safety and welfare** of North Carolina's local communities and environment in many ways. These include improved navigation safety, better resource management and conservation guidelines, sustainable fishing strategies, and access to updated and comprehensive information regarding the Sound's coastal resiliency to climate change. By communicating the findings to local communities and stakeholders, the project also **promotes public awareness and engagement** in environmental stewardship efforts. Finally, based on the insights and lessons learned from this project, NOAA can more confidently plan for future multi-purpose coastal surveys in similar shallow water environments. With continued success, projects like these are likely to improve the efficiency with which we ask and answer questions in the **hydrospatial marketplace**.

NV5's proactive approach ensured that the highest quality bathymetric grid for both water modeling and nautical charting updates would be delivered.

~ CPARS Reviewer